WATERSHED BIOASSESSMENT REPORT

WEST CENTRAL MORGAN COUNTY WATERSHED

Lambs Creek
Sycamore Creek
Highland Creek

April and October 2002

Study Conducted By:

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EXECUTIVE SUMMARY

A rapid bioassessment of the benthic macroinvertebrate communities of four tributaries of the West Fork of White River in Morgan County, Indiana was conducted in April and October 2002. The purpose of the assessment was to document the biological condition of the streams as part of a watershed management program sponsored by the Morgan County Soil and Water Conservation District.

The study showed that 9 of the 10 sites examined on the four streams were impacted, as compared to values from "reference" streams in the same ecoregion. One site, Sycamore Creek at Robb Hill Road, had habitat and a biological community among the best in Indiana.

Although lower aquatic habitat values contributed to biological impacts at some of the other sites (especially an unnamed tributary near Centerton), degraded water quality appeared to be a problem as well. Causes of water quality degradation, as indicated by biological indicators, probably included low dissolved oxygen concentrations (3 sites) and excessive nutrient concentrations (1 site). The sites identified as having the most degraded water quality were all downstream from impoundments. Occasional release of nutrient-rich, anoxic water from these impoundments may be contributing to the problem. Excessive sediment inputs did not appear to be a problem at any site.

Recommendations to improve conditions in the watershed include (1) determining if dam outlet structures on impoundments in the watershed can be modified to allow discharge from surface waters rather than bottom waters, (2) protecting streams from channelization and excessive stream bank tree removal, and (3) continuing to provide high quality wastewater treatment, including nutrient removal, at the Monrovia Wastewater Treatment Plant.

INTRODUCTION

A 319 nonpoint source grant was awarded to the Morgan County Soil and Water Conservation District to assess water quality in several tributaries of the West Fork of White River. One of the streams (Lambs Creek) is on the Indiana Department of Environmental Management's list of "impaired waterbodies" [1]. An important component of the grant was to conduct a series of bioassessments in these streams. Bioassessments are recognized as a valuable tool in identifying water quality problems and helping diagnose their causes [2]. Certain animals are sensitive to different types of stresses. Comparison of the numbers and kinds of animals present can give important clues about the presence of toxic substances, excessive sedimentation, excessive nutrient inputs, or low dissolved oxygen concentrations.

This project was designed to characterize the biological and physical (aquatic habitat) integrity of the streams in West Central Morgan County. Questions to be answered include:

What is the overall ecological health of these watersheds?

Are unhealthy streams affected primarily by degraded water quality or by degraded habitat?

Are dissolved oxygen, pH, temperature, and conductivity within normal ranges for aquatic life?

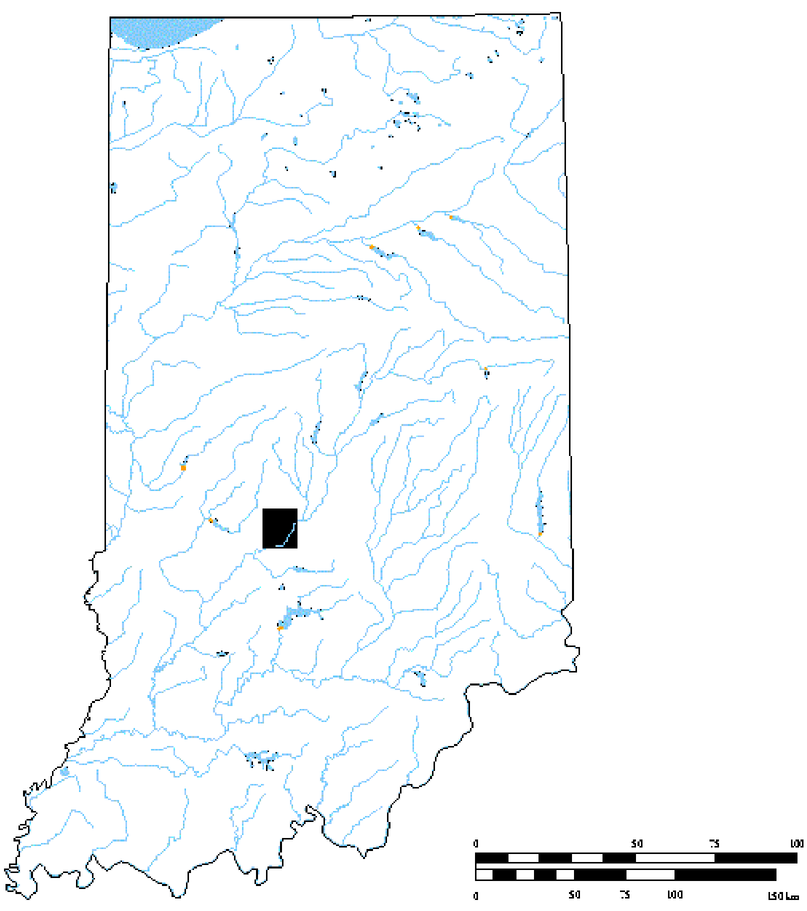
What can be done to make the identified problems better?

Local Setting

The streams in this watershed (Fig. 1) lie in the "Eastern Corn Belt Plain" ecoregion of the Central U.S. This area is composed of a glacial till plain manteled in many places with loess. Stream valleys are generally shallow with narrow valley floors. Constructed ditches and channelized streams are common because much of the ecoregion has poorly drained soils. The natural vegetation consists of a mosaic of bluestem prairie and oak/hickory forest. However, a great majority of the land in this ecoregion is used for agriculture, primarily for corn and soybeans [3].

On a more local level, all of these streams originate in a unique area of glacial outwash at the southernmost end of the last glaciation [5]. Steep slopes on siltstone and shale bedrock have prevented widespread agricultural use and kept most of the watershed in a forested condition.

Figure 1.

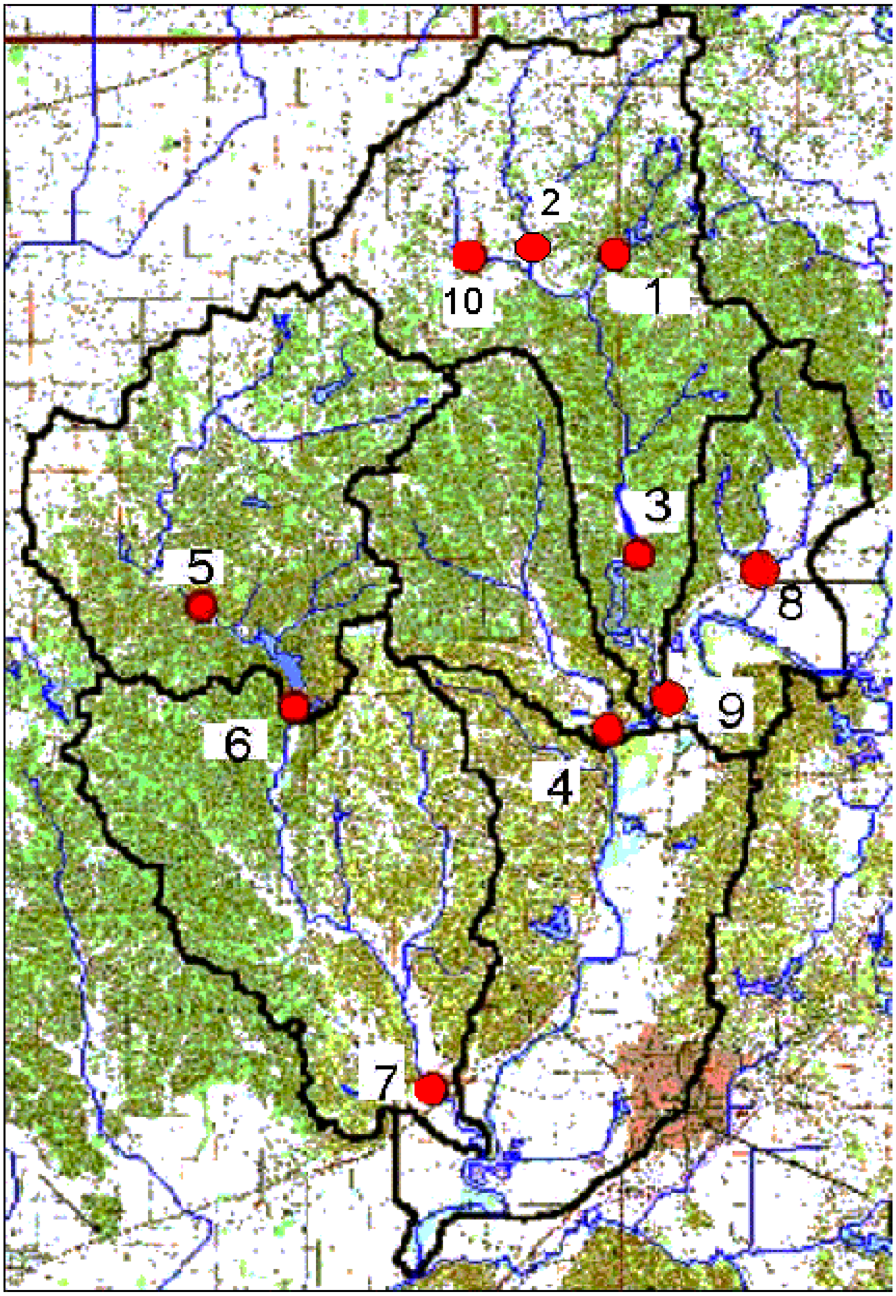


The Present Study

To document the biological integrity of the watershed, nine sites were chosen for study (Fig. 2). A tenth site was added in October 2002, when site 9 became too dry to support a benthic community. Site locations were as follows:

	Stream	Latitude	Longitude
Site 1	Dry Fork of Sycamore Creek below Lake Hart	39.33.658	86.26.441
Site 2	Sycamore Creek CR 950 N	39.33.845	86.27.239
Site 3	Sycamore Creek Robb Hill Road	39.30.792	86.25.923
Site 4	Sycamore Creek State Road 67	39.29.491	86.25.784
Site 5	Highland Creek State Road 67	39.29.634	86.26.840
Site 6	Lambs Creek Upstream from Patton Lake	39.30.526	86.31.696
Site 7	Lambs Creek Downstream from Patton Lake	39.29.021	86.30.363
Site 8	Lambs Creek State Road 67	39.25.286	86.28.449
Site 9	Unnamed tributary near Centerton	39.30.472	86.24.352
Site 10	Unnamed tributary near Monrovia		

Fig. 2. Location of Study Sites



METHODS

AQUATIC COMMUNITY

Because they are considered to be more sensitive to local conditions and respond relatively rapidly to change, benthic (bottom-dwelling) organisms were chosen to document the biological condition of the streams. The U.S. Environmental Protection Agency (EPA) has recently developed a "rapid bioassessment" protocol [4] which has been shown to produce highly reproducible results that accurately reflect changes in water quality. We used a modification of this protocol developed by Ohio EPA [8]. The bioassessment technique relies upon comparison of the aquatic community to a “reference” condition (streams of similar size in the same geographic area which are least impacted by human changes in the watershed). The reference condition for macroinvertebrates in the Eastern Corn Belt Ecoregion were determined by Ohio EPA [8].

Habitat Evaluation

The aquatic habitat at each study site was evaluated according to the method described by Ohio EPA [8]. This method’s results assigns values to various habitat parameters (e.g. substrate quality, riparian vegetation, channel morphology, etc.) and results in a numerical score for each site. Higher scores indicate higher aquatic habitat value. The maximum value for habitat using this assessment technique is 100.

Sample Collection

Macroinvertebrate samples in this study were collected by dipnet in riffle areas where current speed approached 30 cm/sec. All samples were preserved in the field with 70% ethanol.

Laboratory Analysis

In the laboratory, a 100 organism subsample was prepared from each site by evenly distributing the animals collected in a white, gridded pan. Grids were randomly selected and all organisms within grids were removed until 100 organisms had been selected from the entire sample.

Each animal was identified to the lowest practical taxon (usually genus or species). As each new taxon was identified, a representative specimen was

preserved as a "voucher." All voucher specimens will ultimately be deposited in the Purdue University Department of Entomology collection.

Data Analysis

Following identification of the animals in the sample, ten "metrics" are calculated for each site. These metrics are based on knowledge about the sensitivity of each species to changes in environmental conditions and how the benthic communities of unimpacted ("reference") streams are usually organized. For example, mayflies and caddisflies are aquatic insects which are known to be more sensitive than most other benthic animals to degradation of environmental conditions. A larger proportion of these animals in a sample receives a higher score. The sum of all ten metrics provides an individual "biotic score" for each site.

The metrics used in this study were adapted from Ohio EPA [8]. Because Ohio EPA uses a larger sample size in its macroinvertebrate protocol, some of the metrics were modified to more closely correspond to a 100 organism sample. In addition, since a separate qualitative sample was not taken, the U.S. EPA metric "% Dominant Taxon" was substituted for the "EPT Qualitative Taxa" metric used in Ohio. The following scoring values were used in this study:

SCORING VALUES FOR METRICS
Adapted from Ohio EPA and U.S. EPA RBA Protocol III.

	6 points	4 points	2 points	0 points
# of Genera	>20	14 - 20	7 - 13	<7
# Mayfly Taxa	> 6	4 - 6	2 - 4	<2
# Caddisfly Taxa	> 4	3 - 4	1 - 2	0
# Diptera Taxa	>12	8 - 12	4 - 7	<4
% Tanytarsini	>25	11 - 25	1 - 10	0
% Mayflies	>25	11 - 25	1 - 10	0
% Caddisflies	>20	11 - 19	1 - 10	0
% Tolerant Species	0-10	11 - 20	21 - 30	>30
% non-Tanytarsids & non-insects	<25	25 - 45	46 - 65	>65
% Dominant Taxon	<20	21-29	30-39	>40

Because the index scores for macroinvertebrates and habitat result in different maximum values, they are difficult to relate to each other. Therefore, both indices were eventually converted to a normalized score of 0 to 100 using the following formula:

Normalized Score = Actual Score / Maximum Possible Score x 100

RESULTS

Water Chemistry

Table 1 shows a summary of all the water chemistry data collected at the 10 sites examined at least once in this study:

Table 1. Water Chemistry

	Dissolved Oxygen (mg/l)		pH SU		Temp. Deg. C		Cond. uS	
	Apr.	Oct.	Apr.	Oct.	Apr.	Oct.	Apr.	Oct.
Site 1	9.5	7.3	8.3	7.8	22.8	25.8	260	450
Site 2	10.6	10.0	8.3	8.3	23.2	22.1	360	430
Site 3	10.6	10.0	8.6	8,0	22.8	21.1	240	360
Site 4	9.3	6.3	7.5	8.0	20.1	21.7	110	310
Site 5	11.7	7.6	8.8	7.8	23.2	20.2	210	270
Site 6	9.3	6.4	8.3	7.7	20.5	20.8	190	290
Site 7	9.8	3.8	8.1	7.4	22.3	20.1	180	230
Site 8	10.2	8.2	8.8	8.1	24.2	20.2	170	290
Site 9	9.5		8.3		22.7		250	
Site 10		9.2		8.2		21.0		510

Dissolved oxygen, pH, and water temperature fell within ranges tolerable to most forms of aquatic life. Site 7 (Lambs Creek downstream from Patton Lake) had a dissolved oxygen concentration below the Indiana water quality standard (4 mg/l) during October.

Aquatic Habitat Analysis

When the EPA habitat scoring technique was used, the following aquatic habitat values were obtained for each site in the study:

Table 2. Aquatic Habitat

		Score
Site 1	Dry Fork Cr. below Hart Lake	55
Site 2	Sycamore Creek upstream	68
Site 3	Sycamore Creek middle	80
Site 4	Sycamore Creek downstream	76
Site 5	Highland Creek	65
Site 6	Lambs Creek upstream	74
Site 7	Lambs Creek below Patton Lk	79
Site 8	Lambs Creek downstream	69
Site 9	unnamed trib. near Centerton	39
Site 10	unnamed trib. near Monrovia	67

Table 3.
Summary of IBI "Normalized"Scores

		4/02 Score	!0/02 Score	Mean Score	Rank
Site 1	Dry Fork Cr. Below Hart Lake	37	dry	37	8
Site 2	Sycamore Creek upstream	43	50	47	5
Site 3	Sycamore Creek middle	73	70	72	1
Site 4	Sycamore Creek downstream	23	40	32	9
Site 5	Highland Creek	37	57	47	4
Site 6	Lambs Creek upstream	50	67	59	2
Site 7	Lambs Creek below Patton Lake	27	50	39	6
Site 8	Lambs Creek downstream	33	40	37	7
Site 9	Unnamed tributary near Centerton	23	dry	23	10
Site 10	Unnamed tributary near Monrovia		50	50	3

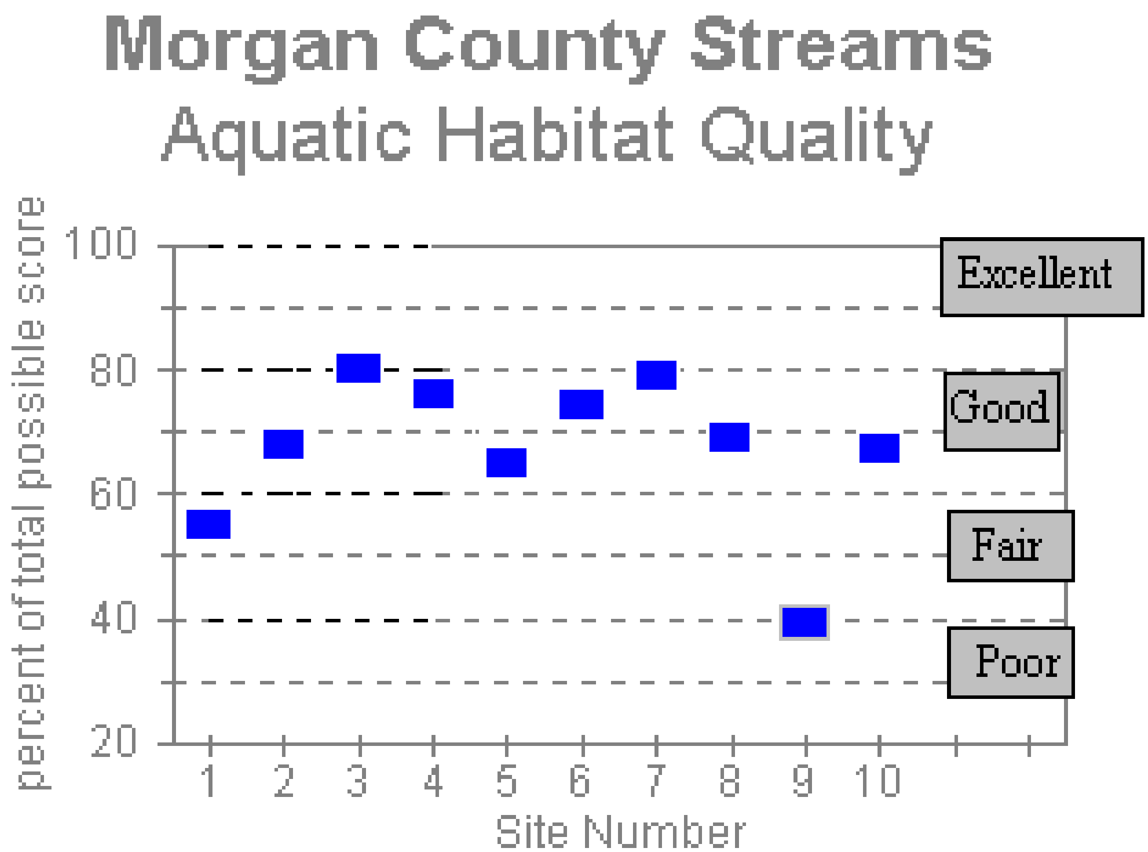
Quality assurance duplicate samples collected at site 3 during April resulted in identical "normalized" IBI scores (73). This indicates that the bioassessment technique was producing reliable, reproducible results during the study period.

DISCUSSION

Aquatic Habitat

Aquatic habitat index values ranged from 39 to 80 at the 10 study sites. According to this scoring scheme, most sites in the watershed have generally "good" aquatic habitat. One site was "excellent," seven were "good," one was "fair," and one was "poor." The site with poor aquatic habitat (the unnamed tributary near Centerton) was artificially channelized, had no shading canopy, and dried up during late summer. None of the other sites had artificially altered channels. Unchannelized headwater streams are rather rare in Indiana.

Figure 3.

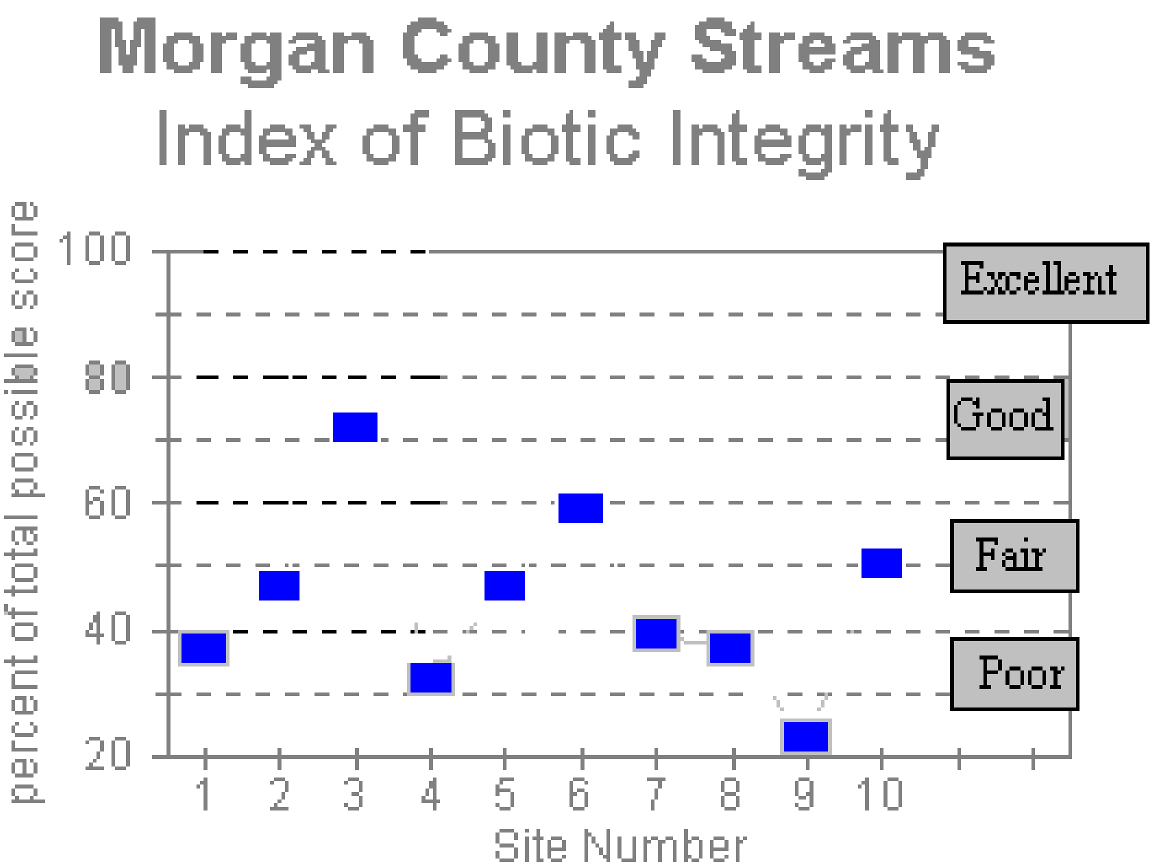


Macroinvertebrate Communities

A total of 49 macroinvertebrate genera were collected at the 10 study sites. The most commonly collected species were riffle beetles (*Stenelmis crenata*), caddisflies (*Cheumatopsyche* spp.), mayflies (*Isonychia sicca* and *Stenonema vicarium*), and midge larvae. Stoneflies were also common during the April sampling period.

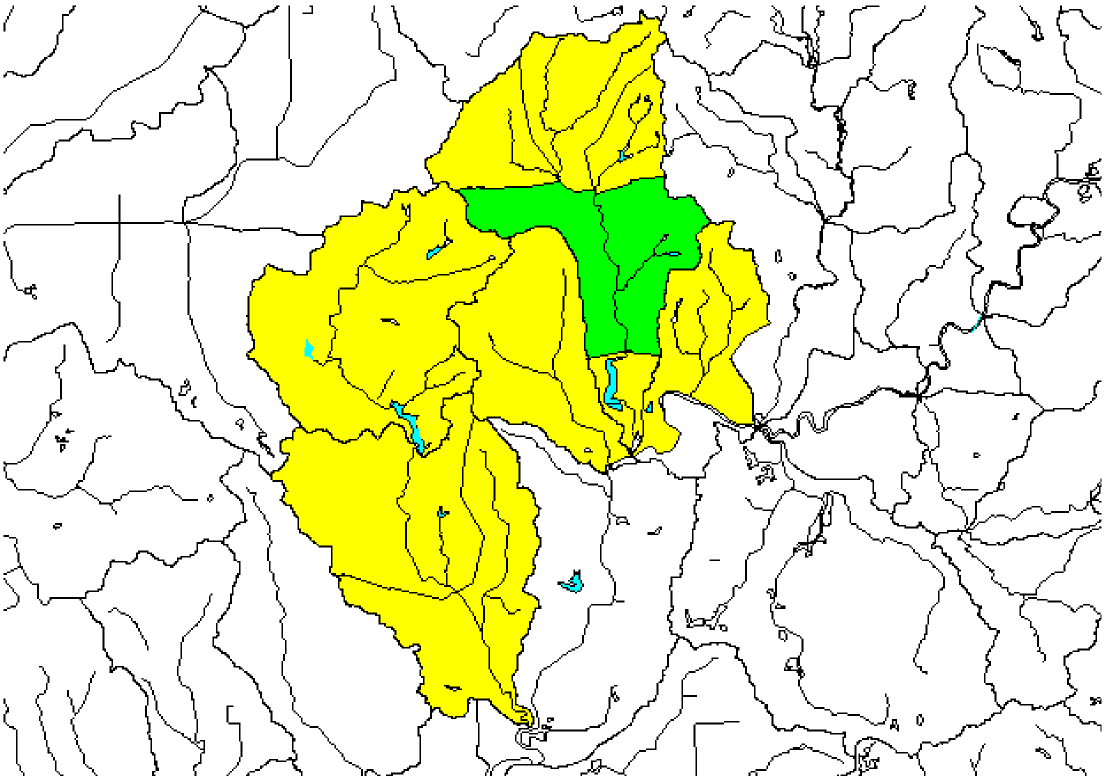
The normalized biotic index scores ranged from 23 to 73 on a scale of 0 to 100. For the yearly mean, two sites fell in the "good" category, four sites were "fair," while four sites had "poor" biotic integrity. It is interesting to note that the IBI scores at many sites were significantly higher during October than during the earlier April sampling period (Table 3). This indicates that water quality conditions generally improved as the year progressed. Sites 4, 5 and 7 showed the biggest improvements during this time.

Figure 4
Only one of the ten study sites (site 3 on Sycamore Creek at Robb Hill Road)



had no aquatic habitat or biological impairment. The watershed represented by this site is shown in green in Fig. 5. This site qualifies as a "regional reference site," having habitat and an aquatic community among the best in Indiana.

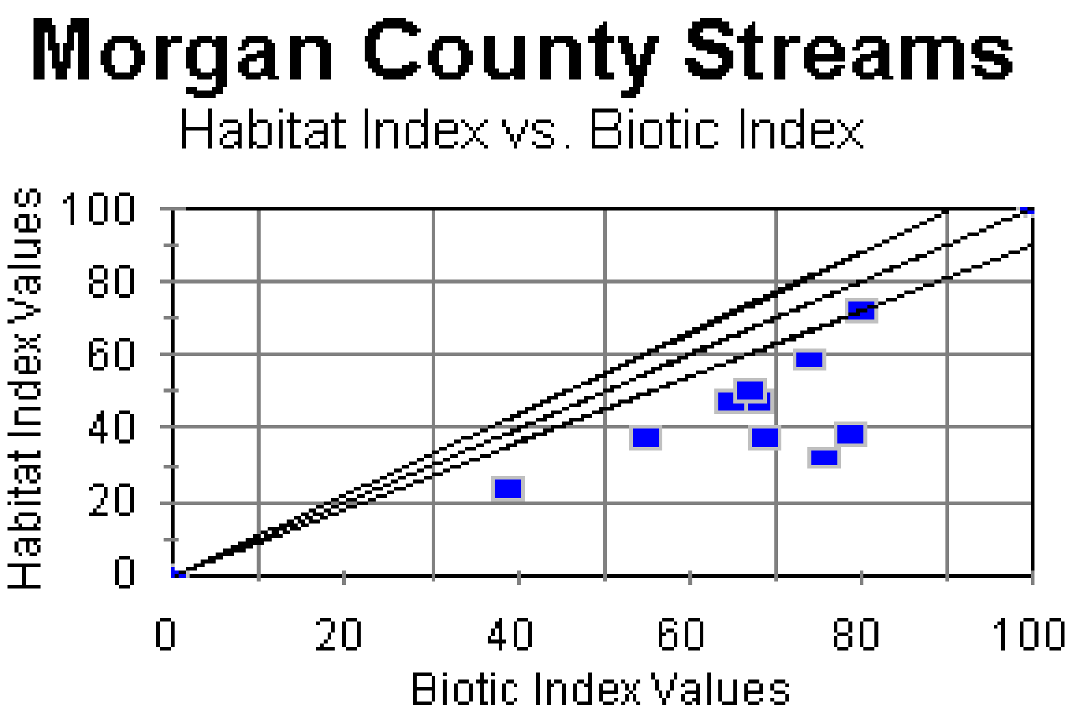
Fig. 5



Diagnosis

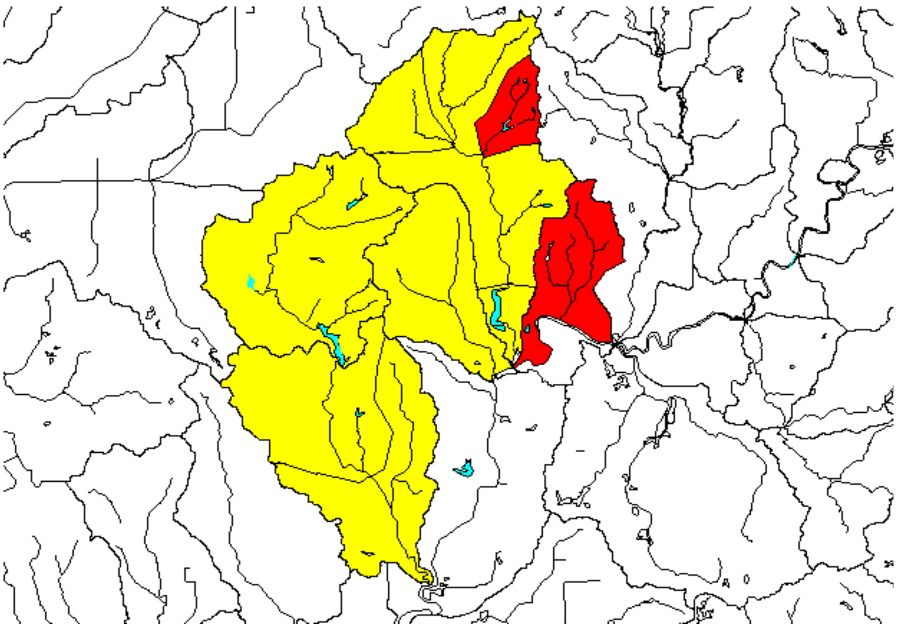
The remaining nine sites exhibited some degree of impairment. One of the most useful aspects of biological monitoring is the ability to use information on the way aquatic animals respond to different types of stress to diagnose a problem. For example, degraded biotic integrity can often be directly related to degraded habitat. Macroinvertebrates cannot thrive where habitat is lacking. When the two values are graphed in relation to each other, they form a straight line [4]. A measurement error of plus or minus 10% can be added to the graph to give a range in which biotic integrity degradation is explained simply by a lack of adequate habitat. When values fall outside this range, however, water quality problems are suspected. A comparison of biotic integrity to habitat is shown in Fig. 6. This figure suggests that nine of the ten study sites had degraded water quality in at least one sampling period.

Figure 6



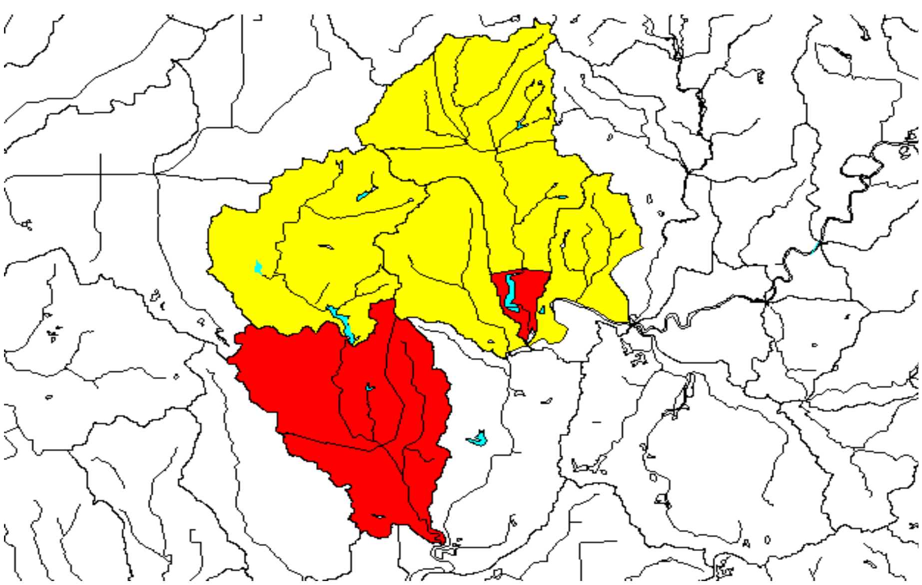
Aquatic life will not thrive were habitat is unsuitable. The watersheds with the lowest aquatic habitat values are shown in Figure 7.

Figure 7.



Three watersheds had biotic index values which were at least 30 points lower than available habitat would allow. These areas, shown in Figure 8, had the most degraded water quality. They include the lower end of Sycamore Creek and the lower end of Lamb's Creek. Both sites are downstream from impoundments.

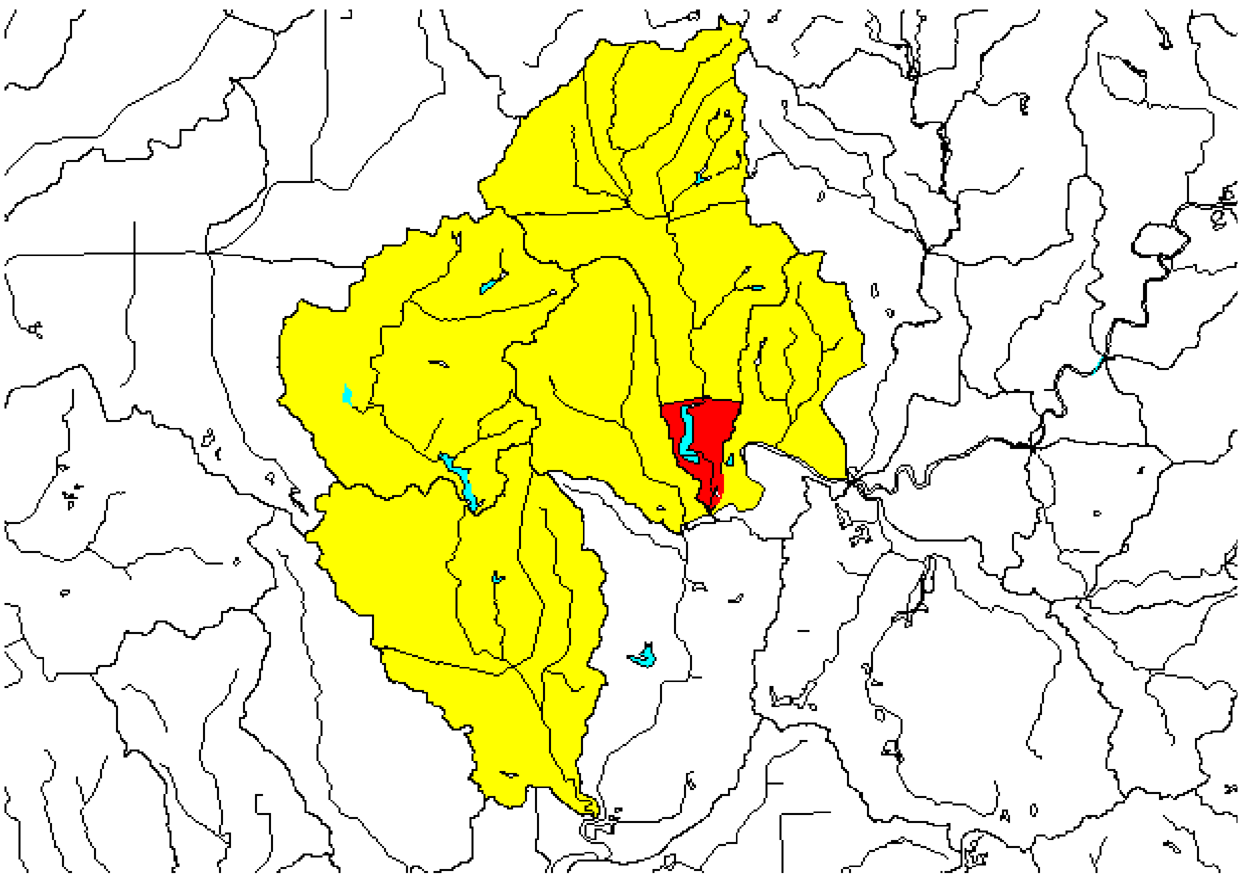
Figure 8



An examination of those metrics showing the lowest values may provide an important clue about causes of biological impairment. No sites were dominated by species known to be tolerant to high amounts of sediment deposition. Instead, sediment-intolerant species were common in most areas. Excessive sediment inputs do not appear to be a problem in these watersheds.

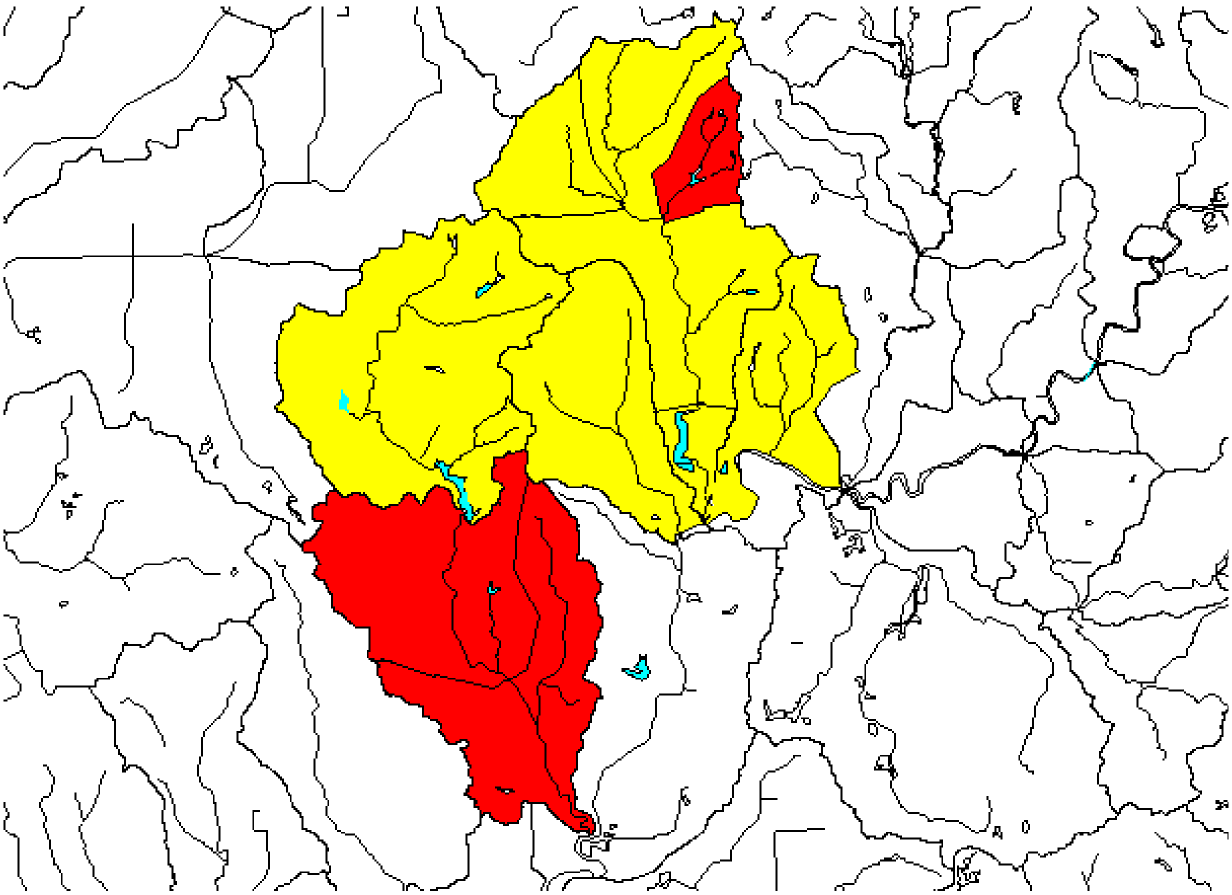
Excessive nutrient inputs are often indicated by a dominance of animals which eat algae ("scrapers"). Dominance by riffle beetles and snails are especially good indicators of this type of impairment [4]. Sites dominated by scrapers and potentially impaired by nutrients are shown in Figure 9.

Figure 9



Low dissolved oxygen concentrations can often be determined by examining the Hilsenhoff Biotic Index for a particular site. This index, which ranges between 0 and 10, is especially suitable for the diagnosis of sewage-related pollution [6]. Sites with values greater than 7 frequently have dissolved oxygen concentrations below 4 mg/l. Watersheds which may be affected by low dissolved oxygen are shown in Figure 10.

Figure 10



RECOMMENDATIONS

1. The sites impaired most by low water quality were downstream from impoundments (Patton Lake and Bradford Woods Lake). The way water is released from impoundments can adversely affect stream quality. For example, if anoxic water high in nutrients is released from the bottom of a stratified lake to a low-flow stream, aquatic life in the stream will be exposed to stressful conditions. Most pollution-sensitive forms will not be capable of living there. In such situations, it would be more beneficial to stream quality if water was released from the surface of the lake. It would be worthwhile to investigate the possibility of changing the dam outlet structures to allow this.

2. The Monrovia Wastewater Treatment Plant, which discharges to a tributary of Sycamore Creek upstream from site 10, does not appear to adversely affect water quality to any large degree at the present time. Good nutrient control, including phosphorus removal to less than 1 mg/l, would help prevent excessive eutrophication of Bradford Woods Lake.

3. Investigate the possibility of enhancing aquatic habitat in the unnamed tributary near Centerton (site 9). This would include reducing the degree of channelization and planting trees along the stream banks.

4. Continue to protect the good aquatic habitat of the remaining streams. Discourage channelization, prevent wholesale tree removal near stream banks, and encourage land use practices which do not add excessive silt to the stream.

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Rapid Bioassessment Results - Macroinvertebrates

Morgan County Benthos - April 2002

	DryFk1	Syc2	Syc 3	Syc4	HldCr5	Lam6	Lam7	Lam8	Trib9	
Chironomidae	68	23	16	25	56	34	65	70	42	
Tipulidae										
Tipula spp.	2		1		1				1	
Hesperoconopa spp.						3	1			
Hexatoma spp.						5			12	
Simuliidae	1	6		3	3	9		6		
Ephemeroptera										
Stenonema vicarium			11	21		2	7		2	
Stenonema femoratum			10				6	2		
Stenacron interpunctatum			2							
Heptagenia sp.				2						
Caenis amica			2							
Isonychia sicca			11			3				
Baetis amplus	1	2						8		
Baetis brunneicolor	2									
Attenella attenuata					1					
Trichoptera										
Cheumatopsyche spp			11		1		1	2		
Certatopsyche bifida			5							
Hydropsyche betteni		1		1						6
Pycnopsyche sp.			1		1					
Rhyacophila spp.	6	15	2			2				
Plecoptera										
Isoperla nana			3		3	1				
Isoperla confusa						5		1		
Isoperla duplicata								1		
Allocapnia sp.						1				
Hydroperla fugitans					23					
Amphinemura venosa	4	41	9	2	5	5	2	2		
Perlesta placida							1			
Megaloptera										
Corydalus cornutus			1							
Odonata										
Gomphus sp.			1							
Coleoptera										
Stenelmis crenata	6		1	68	3	13			8	
Stenelmis sexlineata								20		
Macronychus glabratus					1			4		
Psephenus herricki			1			12				
Gastropoda										
Physella gyrina									14	
Fossaria modicella									3	
Oligochaeta (Tubificidae)									1	
Hirudinea		1								
Amphipoda										
Hyalella azteca	4		1				2	2		
Isopoda										
Lirceus spp.	4	2							13	
Caecidotea spp.							2			
Total	100	100	100	100	100	100	100	100	100	

Morgan County Benthos - October 2002

	DryFk1	Syc2	Syc 3	Syc4	HldCr5	Lam6	Lam7	Lam8	Trib9	Mon10
Chironomidae			18	14	24	10	35	42		7
Tipulidae										
Tipula spp.		6	1		12	4	6	6		2
Antocha spp.						3				1
Simuliidae				1		3				
Ephemeroptera										
Stenonema vicarium			24	23		12			1	1
Stenonema femoratum		1	11		19	29	5			1
Stenacron interpunctatum		1	1				4	1		
Caenis amica		1			4	2	8			
Tricorythodes spp.			1	1						
Isonychia sicca		51	2		8					
Baetis flavistriga		2		1						
Baetis brunneicolor				1						
Trichoptera										
Cheumatopsyche spp		6	28	1	11	12	4	1		57
Certatopsyche bifida										
Hydropsyche betteni				1		1	11	1	3	26
Chimarra obscura		3	4							2
Megaloptera										
Corydalus cornutus		1		2		1				
Odonata								1		
Boyeria vinosa					1					
Calopteryx spp.			1				4			
Ischnura spp.							2			
Progomphus spp.								1		
Coleoptera										
Stenelmis crenata				2		1				
Stenelmis sexlineata					2				3	
Stenelmis larvae			3	74	3	8	19			2
Dubiraphia larvae			1							
Optioservus spp.		2				1	1	2		
Psephenus herricki		2			3	14				
Berosus spp.								3		
Gastropoda										
Physella gyrina			3		1		1			
Ferrissia spp.							7	6		
Pelecypoda										
Corbicula fluminea				1				29		
Oligochaeta										
Lumbriculidae							1			
Hirudinea								1		
Decapoda										
Orconectes spp.					1	1				
Amphipoda										
Hyalella azteca							1			
Isopoda										
Caecidotea spp.			2							1
Lirceus spp.								1		
Total	NO FLOW	100	100	100	100	100	100	100	DRY	100

Data Analysis for Macroinvertebrates - 4/02

METRICS

	Site # 1	2	3	4	5
# of Genera	12	7	19	5	12
Mayfly Taxa	2	2	5	1	2
Caddisfly Taxa	2	1	5	0	2
Diptera Taxa	4	4	4	4	6
% Tanytarsini	1	1	0	0	0
% Mayflies	3	13	46	2	3
% Caddisflies	7	15	20	0	2
% Tolerant Species	1	0	0	0	0
% non-Tanytarsid midges & non-insects	77	25	17	25	56
% Dominant Taxon	34	41	21	68	23

SCORING

	Site # 1	2	3	4	5
# of Genera	2	2	4	0	2
# Mayfly Taxa	2	2	4	0	2
# Caddisfly Taxa	2	0	6	0	2
# Diptera Taxa	2	2	2	2	2
% Tanytarsini	2	2	0	0	0
% Mayflies	2	4	6	2	2
% Caddisflies	2	4	6	0	0
% Tolerant Species	6	6	6	6	6
% non-Tanytarsid midges & non-insects	0	4	6	4	2
% Dominant Taxon	2	0	4	0	4
SCORE	22	26	44	14	22
STANDARDIZED SCORE	37	43	73	23	37

Data Analysis for Macroinvertebrates - 4/02

METRICS

	Site # 6	7	8	9	3-d
# of Genera	13	9	11	9	18
Mayfly Taxa	2	1	3	0	3
Caddisfly Taxa	1	1	1	1	4
Diptera Taxa	8	4	4	6	4
% Tanytarsini	0	0	0	2	1
% Mayflies	10	6	12	0	49
% Caddisflies	2	1	2	6	26
% Tolerant Species	0	2	0	28	0
% non-Tanytarsid midges & non-insects	34	69	72	73	11
% Dominant Taxon	17	32	35	21	29

SCORING

	Site # 6	7	8	9	3-d
# of Genera	2	2	2	2	4
# Mayfly Taxa	2	0	2	0	2
# Caddisfly Taxa	0	0	0	0	4
# Diptera Taxa	4	2	2	2	2
% Tanytarsini	0	0	0	2	2
% Mayflies	4	2	4	0	6
% Caddisflies	2	2	2	2	6
% Tolerant Species	6	6	6	2	6
% non-Tanytarsid midges & non-insects	4	0	0	0	6
% Dominant Taxon	6	2	2	4	4
SCORE	30	16	20	14	44
STANDARDIZED SCORE	50	27	33	23	73

Data Analysis for Macroinvertebrates - 10/02

METRICS

	Site # 1	2	3	4	5
# of Genera		12	15	11	13
Mayfly Taxa		6	5	3	3
Caddisfly Taxa		2	3	1	2
Diptera Taxa		2	4	4	4
% Tanytarsini		1	0	0	0
% Mayflies		80	38	3	43
% Caddisflies		9	33	1	12
% Tolerant Species		0	5	0	1
% non-Tanytarsid midges & non-insects		0	23	15	26
% Dominant Taxon		51	28	74	19

SCORING

	Site # 1	2	3	4	5
# of Genera		2	4	2	2
# Mayfly Taxa		4	4	2	2
# Caddisfly Taxa		2	4	2	2
# Diptera Taxa		0	2	2	2
% Tanytarsini		2	0	0	0
% Mayflies		6	6	2	6
% Caddisflies		2	6	2	4
% Tolerant Species		6	6	6	6
% non-Tanytarsid midges & non-insects		6	6	6	4
% Dominant Taxon		0	4	0	6
SCORE		30	42	24	34
STANDARDIZED SCORE	NO FLOW	50	70	40	57

Data Analysis for Macroinvertebrates - 10/02

METRICS

	Site # 6	7	8	9	10
# of Genera	14	16	14		10
Mayfly Taxa	2	3	2		2
Caddisfly Taxa	2	2	2		3
Diptera Taxa	8	4	4		6
% Tanytarsini	0	0	0		0
% Mayflies	31	17	2		2
% Caddisflies	23	5	4		83
% Tolerant Species	0	10	7		1
% non-Tanytarsid midges & non-insects	11	46	77		8
% Dominant Taxon	29	19	29		57

SCORING

	Site # 6	7	8	9	10
# of Genera	4	4	4		2
# Mayfly Taxa	2	2	2		2
# Caddisfly Taxa	2	2	2		4
# Diptera Taxa	4	2	2		2
% Tanytarsini	0	0	0		0
% Mayflies	6	4	2		2
% Caddisflies	6	2	2		6
% Tolerant Species	6	6	6		6
% non-Tanytarsid midges & non-insects	6	2	0		6
% Dominant Taxon	4	6	4		0
SCORE	40	30	24		30
STANDARDIZED SCORE	67	50	40		50
				DRY	

Habitat Evaluation Breakdown

	Site Number									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
SUBSTRATE	12	12	12	12	8	12	12	10	6	12
COVER	6	8	8	9	8	8	9	8	5	8
CHANNEL	13	13	12	13	13	13	14	12	7	12
RIPARIAN	8	13	18	18	12	14	17	12	5	12
POOL/RIFFLE	2	10	12	12	10	11	11	12	2	11
GRADIENT	8	6	10	4	8	8	8	6	8	6
DRAINAGE AREA	6	6	8	8	6	8	8	9	6	6
TOTAL	55	68	80	76	65	74	79	69	39	67

The sites with the two lowest habitat scores (1 and 9) became nearly or completely dry during the October 2002 sampling period.

BIOASSESSMENT SUMMARY

Lambs, Sycamore, and Highland Creeks Morgan County, Indiana

Purpose

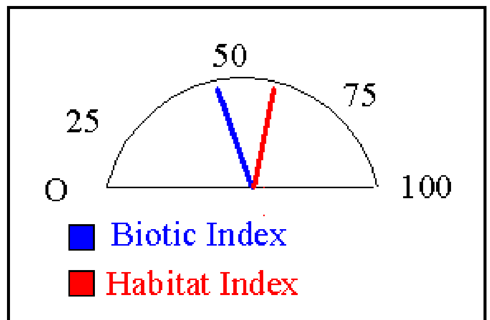
To measure the ecological integrity of Lambs, Sycamore and Highland Creeks in Morgan County, Indiana. A bioassessment technique was employed. Bioassessment uses knowledge of the biology of stream-dwelling animals to measure stream health.

Watershed Characteristics

The watershed is primarily forested. Residential use is rapidly increasing.

Results

Water quality and habitat are among the best in Indiana at one site. Other sites are affected by degraded water quality or habitat. Water quality problems include excessive nutrients and low dissolved oxygen.



Watershed Gauge
A score of 100 is our goal

Recommendations

Sites downstream from lakes have the most severe water quality impacts. Work with lakes associations to re-design dams to release surface water. Protect stream channels and stream bank vegetation.

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Date: April and October 2002